SRI International

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Covering the Period 1 February through 28 February 2011

POWER MEMS DEVELOPMENT

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Submitted in accordance with Deliverable A001 - Monthly Technical and Financial
SRI Project P19063

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MICROELECTROMECHANICAL SYSTEMS (MEMS) RESETTABLE CIRCUIT BREAKER (TASK 1.1) AND MEMS SWITCH FOR DC-DC VOLTAGE CONVERTERS (TASK 1.2)

Task 1.1 Contributors: Sunny Kedia, Weidong Wang, Susana Stillwell

Task 1.1 Deliverable: 10 prototype packaged MEMS-based resettable circuit breakers for testing and analysis in the Office of Naval Research (ONR) laboratories.

Task 1.2 Contributors: Sunny Kedia, Christel Munoz, Weidong Wang, Scott Samson, Drew Hanser

Task 1.2 Deliverable: Functional MEMS-based DC-DC converter in a vacuum package.

Summary: In Task 1.1, we were able to fabricate two silicon-on-insulator (SOI) wafers and two double-side-polished (DSP) wafers. The fabricated wafers were bonded and then released and tested for circuit breaker configuration. The first bonded wafer pair failed during the deep reactive-ion etching (DRIE) release step due to insufficient masking material. This bonded wafer pair was processed in SRI's MicroSystems Engineering Laboratory in Menlo Park, CA (MSEL-West), where the selectivity of etching silicon to silicon oxide is lower due to variations in the process resulting from equipment set differences. The second bonded wafer pair, which was processed in MSEL-East (Largo, FL), released as expected. During testing we observed that a few cantilevers acted as circuit breakers; however, we were not able to obtain resettable circuit breakers. We will present a detailed analysis of the test results in next month's report.

In Task 1.2, we simultaneously processed three versions of wafers. Wafers processed in Task 1.1 also contained voltage multiplier switches. During testing of the resettable circuit breaker switches, we found that the cantilevers actuate and perform as breakers as we indicated by the circuit resistance changing from 10 MΩ to 200 Ω following actuation at 19 V. More testing on those devices is currently in progress. In the second version, an additional mask was designed to etch the bulk silicon under the MEMS plate to keep the plate from moving toward the substrate. Wafers processed in this version failed during the structure silicon etch step. In MSEL-West, the 4–in. wafer is mounted on a 6–in. wafer for DRIE. During this step the resist that was in place to protect the structure got burned due to overheating in the etch process, and the springs connecting the plates to the anchor were etched away. Finally, we developed a new method of processing, involving fewer tools and faster turnaround, using two of the Version 1 masks. The process deposits first a trace metal (Cr/Au), and then a contact metal (Cr/Pt). These deposits are followed by a sacrificial polymer (ProLIFT), a top metal to contact the trace metal, and finally the structure material (silicon oxynitride). The fabricated wafer was then released. Following our initial process run, the switches were in contact. We are looking at different structure layers that can make the switches open initially, and then close upon application of voltage.

This month we also developed a Version 3.1 (V3.1) design for the DC-DC converter. The V3.1 switch design utilizing a sacrificial polymer layer was completed, and the photomasks were received. Portions of the process flow were characterized on two test wafers. Process flow validation was begun on six wafers, three of which completed fabrication, dicing, and release and are currently undergoing electrical testing. We used two different structural layer materials—silicon oxide and silicon oxynitride—to obtain low-stress films that will result in flat released switches. A Wyko interferometry scan of the silicon oxide structures showed switch curvature of 4 μm, indicating a fairly low amount of stress in the oxide layer. Initial electrical test results indicate that the contact pads were electrically connected to the electrostatic

electrodes and that mechanically connecting the top and bottom switch contacts resulted in a contact resistance of about 50 ohms. Further electrical testing and process flow evaluation will continue in March.

DIAMOND HEAT SPREADER OR HEAT SINK FOR HIGH-POWER MEMS SWITCH APPLICATIONS (TASK 1.3)

Contributors: Priscila Spagnol, Shinzo Onishi, Drew Hanser, Weidong Wang, Sunny Kedia, John Bumgarner

Deliverable: Prototype device fabricated on a thin-film diamond heat spreader layer and individual samples of diamond on Si or other suitable substrates for material evaluation.

Summary: No work was done this month on Task 1.3.

POSITRON TRAPPING AND STORAGE (TASK 2)

Contributors: Ashish Chaudhary, Friso van Amerom, Tim Short

Deliverable: A minimum of four MEMS-based trap structures for radio frequency (RF) trapping of electrons.

Summary: No work was done this month on Task 2.

FINANCIAL STATUS

R&D Status Report

Program Financial Status

15 July 2009 through 26 February 2011

Contract Item No.	Current Funding	Current Period Expenses	Cumulative Expenses	% Budget Complete
0001	$1,829,849	$16,373	$1,611,822	88%
Project Commitments		(4,528)	214,207	
Total	$1,829,849	$11,845	$1,826,029	

Based on currently authorized work:

Is current funding sufficient for the current fiscal year (FY)? (Explain if NO) **Yes**

What is the next FY funding requirement at current anticipated levels **N/A** (**base fully funded)**